DATRAN A110

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DATRAN of ALLEGO

DIGITAL STRAIN INDICATOR

MODEL A — 110

OPERATION & MAINTENANCE

ALLEGANY INSTRUMENT COMPANY
Los Angeles, California

Manufactured
By

AUTOMATION INDUSTRIES, INC.
Datran Division
Paramount, California

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DIGITAL STRAIN INDICATOR

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1. GENERAL DESCRIPTION

The Model A–110 Digital Strain Indicator is designed to fulfill the requirements for an accurate, rapid method of measuring incremental resistance variations in an external bridge circuit. The design of the instrument is such that its maximum utility will be realized when it is used with 120 ohm strain gage circuits. Any resistive bridge circuit in the range from 50 to 1000 ohms is acceptable, however. Scale calibration is in terms strain in microinches per inch when the indicator is used with most of the common strain gages. Readout is by means of a mechanical instrument counter, with automatic shutter action for reversible polarity signals.

CIRCUITS

The Model A–110 Digital Strain Indicator is a servo-balanced instrument, and is completely self-contained, including a DC bridge power supply. The servo-balancing voltage is derived directly from the bridge power. In this manner, the calibration is essentially independent of power supply variations.

A full four-arm bridge must be employed as input to the measuring circuit, as shown in Figure 1. The instrument is also able to accomodate half-bridge or 120 ohm quarter-bridge inputs, in which case R-3 and R-4, or R-2, R-3 and R-4 are replaced by precision resistors built into the instrument.

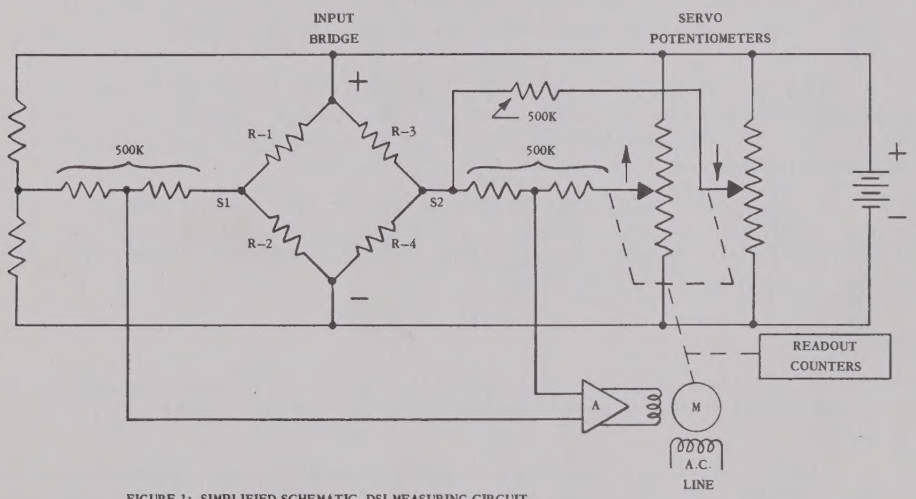

FIGURE 1: SIMPLIFIED SCHEMATIC, DSI MEASURING CIRCUIT

A precision attenuator is provided in the servo-balancing circuit to enable range changing, and to enable the direct reading of strain for 1, 2 and 4 active arms in an input strain gage bridge. Each count of the digital readout represents nominally 1 microinch per inch strain for a single active arm bridge, on MULTIPLIER 1 setting. Other calibrations, in microinches strain per count, are directly proportional to the MULTIPLIER setting, and are inversely proportional to the number of active arms.

Mathematically: $\text{Microinches strain} = \text{counts} \times \frac{\text{MULTIPLIER Setting}}{\text{No. of active arms}}$

In addition to the fixed attenuator, a gage factor control allows the range to be set at any desired value between –12.5% and +12.5% of the nominal range of the instrument. This feature permits the instrument to be calibrated directly in micro-inches per inch when using gages having gage factors between 1.75 and 2.25. For convenience in using the instrument this control is calibrated to read gage factor directly.

AMPLIFIER AND MOTOR

The servo amplifier utilizes a 60 cycle chopper modulator and a high gain AC amplifier. Maximum overall gain is greater than one million. The two phase servo motor is driven from a balanced output stage. The reference phase of the motor is supplied from the AC line through a phase shifting capacitor (for 90° phase shift).

POWER SUPPLIES

All necessary power supplies are incorporated in the instrument. Regulated power supply voltages are not required due to the design principles employed. DC bridge voltage is highly filtered to minimize coupling between the instrument input circuits and the 60 cycle power line.

2. THEORY OF OPERATION

INPUT CIRCUIT CONSIDERATIONS

The Digital Strain Indicator (hereafter referred to as the DSI) is designed to measure incremental changes of resistance, or Δ R/R, essentially independent of the actual value of initial bridge resistance R. For example, a 1 ohm change of a resistor in a 100 ohm bridge gives the same indication as a 2 ohm change of a resistor in a 200 ohm bridge. The instrument measures only changes in an external bridge, and absolute resistance is not measured except by comparison with some known fixed resistance in the external circuit. Equal resistance change in all arms of an external bridge (all arms increasing or all arms decreasing) will give no resultant indicator reading. The instrument may also be conveniently thought of as an extremely sensitive indicator of resistance ratio.

Referring to Figure 1, it should be noted that the instrument balancing voltage is derived from a high-impedance shunt (500,000 ohms) across one arm of the input bridge. Changes in bridge supply voltage have exactly the same effect on balancing voltage as on the bridge output voltage. Therefore, the calibration is independent of supply voltage over wide limits.

As shown in the simplified schematic, the servo drives a dual potentiometer in which the two sections are connected in parallel, but with reversed polarity. The dual potentiometer arrangement is necessary in order to maintain calibration for all possible values of bridge resistance from 50 to 1000 ohms. Refer to the attached schematic diagram for exact details of the wiring.

SERVO OPERATION

The operation of the servo amplifier and motor is conventional in most respects. Excellent stability is achieved through the use of an R-C damping network in the input circuit, and by employing a low-inertia, high torque control motor.

The front panel servo gain control should be adjusted for optimum servo performance. When switching from low to higher MULTIPLIER settings, it may be necessary to reduce the gain to prevent excessive oscillation about the servo balance point.

3. OPERATING PROCEDURE

The indicator is ordinarily shipped ready for operation. The power cord and input plug are detached, but are packed with the indicator. Before placing the instrument in actual operation, it is advisable to inspect for any possible damage or loosening of parts that might have occurred in transit.

OPERATING CONTROLS

The operation of the various instrument controls is presented in tabular form in Table 1.

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TABLE 1: OPERATING CONTROL SUMMARY

CONTROL NAME	CONTROL FUNCTION
1. Servo Gain	Adjusts servo gain for optimum response. (Set to just under the point of servo oscillation)
2. Multiplier	Selects instrument calibration.
a. 1, 2, 4, 10, 100	Nominally 0.5 to 50 millivolts per volt.
3. Gage Factor	Continously variable vernier on MULTIPLIER setting.
a. Range of control is from −12.5% to +12.5% of nominal (for strain gages, gage factor of 1.75 to 2.25)	
4. Bridge	Selects either full or half bridge inputs.
a. Full	Complete four-arm bridge wired externally.
b. Half	Precision network in instrument completes bridge.
5. Fine Balance	Adjusts resistive balance of input bridge for zeroing of indicator.
6. Coarse Balance	Selects proper range of balance control for various conditions.
a. Ext.	For use with external balance circuit.
b. 0	For use with well-balanced bridges.
c. −2 or +2	For use with poorly balanced bridges.
d. −6 or +6	For use with badly unbalanced bridges.
7. Calibration Check	Provides a precision 60K ohm shunting resistor from S1 to positive bridge power lead (resulting in downscale indicator reading).
8. Check Instrument Zero	Push button to short-circuit S1 and S2 to check instrument zero offset.
9. Set Instrument Zero	Screwdriver adjustment for setting electrical zero to coincide with mechanical zero.

In addition to the control functions outlined in this Table 1, further clarification of the meaning of the numerical values indicated on the MULTIPLIER, GAGE FACTOR and BALANCE CONTROLS follows:

MULTIPLIER:

A multiplying factor to be applied to the nominal instrument span of 0.500 millivolts per volt per 1000 counts (note that this nominal calibration is subject to a ±12.5% adjustment according to setting of the GAGE FACTOR control). When a single active arm strain gage input is employed, the MULTIPLIER setting also indicates the number of microinches per inch strain which is represented by each count of the digital readout counter. The accuracy of this last relationship deteriorates for large strains, however, due to non-linearity between strain and output voltage.

GAGE FACTOR:

This control is arranged to adjust the millivolt per volt calibration of the DSI in accordance with the standard definition of "Gage Factor" as it is used by strain gage manufacturers. For any combination of GAGE FACTOR and MULTIPLIER SETTINGS, the span(for 1000 counts) is given by:

$$\text{Span} = \frac{(\text{GAGE FACTOR})\ (\text{MULTIPLIER})}{4} \text{ millivolts per volt.}$$

When the GAGE FACTOR control is set to the value specified by a strain gage manufacturer, the millivolt per volt calibration is automatically varied to provide readout directly in microstrain.

COARSE BALANCE:

Provides an adjustable offset for the range of the FINE BALANCE potentiometer. There are five positions, giving nominally zero, ±2000 microstrain and ±6000 microstrain offset for center position of the FINE BALANCE control. An EXT. position disconnects the instrument balance circuits entirely.

FINE BALANCE:

A ten-turn vernier control to achieve exact bridge balance. The reading of the control knob is for reference only, and is not intended to represent a quantitative value of a variable. The control range in terms of microstrain per turn is also quite nonlinear, expecially for the ±2 and ±6 settings of COARSE BALANCE. Sufficient overlap is provided between the settings of COARSE BALANCE and the ends of the FINE BALANCE potentiometer to insure continuity of adjustment.

Internal adjustment controls are provided as follows (these require adjustment only infrequently, at periods of routine maintenance or calibration):

1. Calib. Adjust. . . . . Screwdriver adjustment, accessible from top of chassis, for bringing instrument into exact calibration.
2. Gage Factor Range . . . . . Screwdriver adjustment, accessible from top of chassis, for an exact 9:7 range of GAGE FACTOR control.

CONNECTIONS

Input connections are made to the binding posts on the front panel or the receptacle on rear of chassis as follows:

BINDING POST	RECEPTACLE	CONNECTION
+	Pin A	Positive Power
S1	Pin B	Signal Lead 1
D	Pin C	Dummy Resistor
–	Pin D	Negative Power
S2	Pin E	Signal Lead 2
	Pin F	Internal Half-Bridge
⏚	Pin H	Chassis Ground

For half bridge inputs, pin B or post S1 is the signal lead, and pin E or post S2 is not used since internal resistors complete the bridge. Positive instrument reading will result from Signal Lead 1 being of negative voltage with respect to Signal Lead 2. Care should be taken to minimize lead resistances since they can introduce appreciable errors.

To insure adequate servo performance, 60 cycle pickup on signal leads should be kept at a minimum. Symptoms of 60 cycle pickup are sluggish servo response near the balance point, excessive "buzz" of the servo motor, etc. Careful attention should be given to grounding of the instrument case and of any metallic structures to which strain gages are attached. A ground on the power plug of the DSI is provided to ground the chassis. Failure to use this grounding provision may result in appreciable instrument zero offset. However, the strain gages, or leads, should NOT be conductively grounded at any point. Shielding of leads is advisable for long lengths.

The built in half bridge is 240 ohms. For minimum pickup the resistance of both halves of a bridge should be the same. It may be necessary to complete a half bridge externally with the proper value resistors, if excessive pickup is a problem when using high resistance gages.

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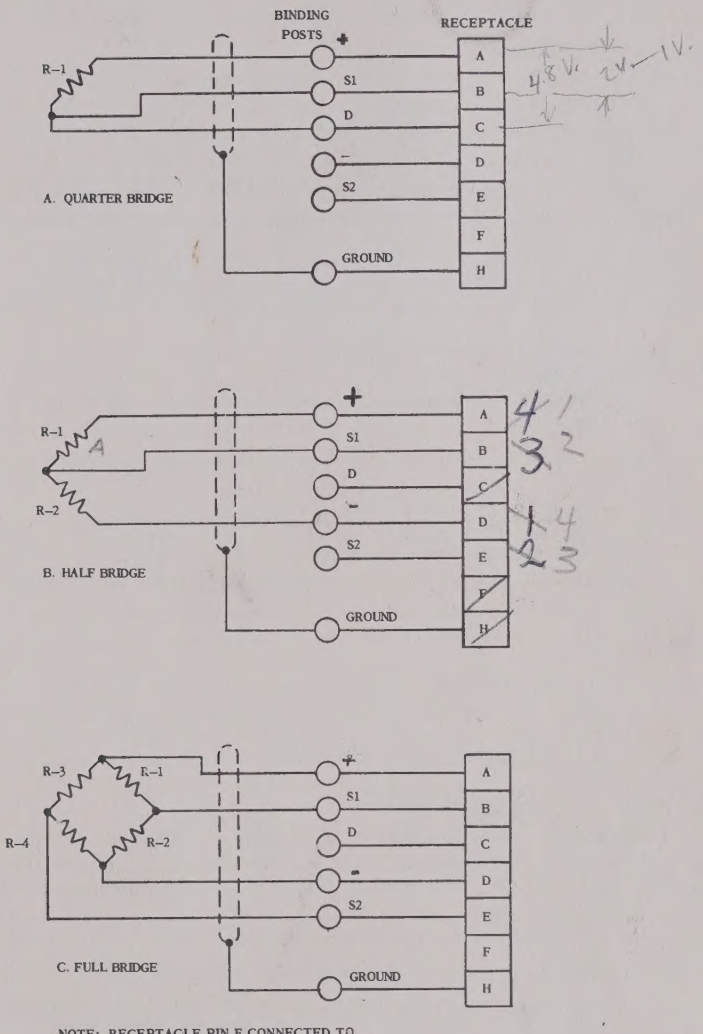

NOTE: RECEPTACLE PIN F CONNECTED TO
INTERNAL HALF BRIDGE OF DS1,
FOR USE IN MULTI–CHANNEL SYSTEMS

FIGURE 2: INPUT WIRING

A four-pin socket is provided at the rear of the instrument chassis, labeled REF. (– +) and PWR. (– +). For routine measurements, the "+" and "–" pins may be jumpered by means of the plug provided for this purpose. Under some conditions, however, where many bridges are to be supplied with power, or where lead lengths are long, it is desirable to distribute bridge power to minimize error-producing voltage drops. It is important to remember that, although the DSI measuring circuit is designed to be independent of variations in bridge voltage, to maintain proper calibration, bridge voltage and DSI measuring voltage must be identical. Voltage losses in high resistance lead wires can be a source of appreciable error.

Socket connections are as follows:

PWR (– +): These socket pins are connected to a source of rectified and filtered D.C. voltage for bridge excitation. Up to four 120 ohm bridges may be supplied in parallel from this source; however, voltage appearing at the actual bridge locations should be returned to the REF. (– +) terminals to eliminate the effect of voltage drop in the supply leads. For externally supplied bridge excitation the jumper plug should be removed.

A second four-pin socket is provided at the rear of the instrument chassis, labeled CALIB. A plug for this socket is provided with a 60K ohm ±.05% resistor wired between pins 2 and 3. The plug may be replaced or rewired to permit shunting of any other bridge arm (Fig. 2C) when the CALIBRATION CHECK pushbutton is operated.

BRIDGE SUPPLY VOLTAGE

To minimize noise and hum voltages which would adversely affect the performance of the servo amplifier, the bridge excitation voltage must be extremely well filtered. Under some conditions, where many low resistance bridges are supplied from the DSI, power supply ripple may increase appreciably. To reduce power supply ripple, it will be necessary to add additional filter capacitors across PWR (– +) terminals (minimum of 6000 mfd. at 15 volts). If a total current of greater than one-quarter ampere is being drawn, it is advisable to supply the bridges from an external source, such as a battery or a special low ripple power supply. To use an external source, remove the jumper plug and return external bridge voltage to the REF (– +) terminals (+ and – binding posts or Pins A and D of the input plug).

CONTROL CONNECTOR

When the DSI is supplied for use in an automatic printout system, a 12-pin control connector is mounted at the rear of the instrument. Switch contacts, representing positions of the MULTIPLIER control, are brought out for automatic recording. Also, the control winding of the 2-phase servo motor is brought out for the purpose of stopping the servo motor during readout.

4. INTERPRETATION OF MEASUREMENTS

When strain gage inputs are employed, it is usually possible to set the instrument calibration to read out directly in microinches per inch. However, care must be taken to account for the number of active bridge arms and for strain gage "gage factor". In addition, where temperature compensating gages are attached to a structure at right angles to active gages, strain due to Poisson's ratio must be considered. Referring to Figures 1 and 2, the instrument reading will increase in the positive direction for tension in bridge arm R–1.

The relationship between average strain and instrument readings, as previously given is:

$$\text{Strain in microinches per inch} = \text{Counts} \times \frac{\text{MULTIPLIER Setting}}{\text{No. of Active Arms}}$$

If the MULTIPLIER setting is equal to the number of active arms, then strain is given directly. For large signals using a single active arm, the MULTIPLIER may be set to 10 or 100 which results in each count being equal to nominally 10 or 100 microinches per inch strain. For other combinations of MULTIPLIER settings and active arms, the counts may have to be multiplied by 2, 2.5, 4, 5, 25 or 50 or divided by 2 or 4, as the case may be, in order to arrive at the correct value of strain.

GAGE FACTOR CORRECTION

Since gage factor will vary between the many available types of strain gages, it must be taken into account either by correction of data, or by a variable control which can be set to a specified value. The GAGE FACTOR control of the DSI is a continuously variable multiplier that is calibrated to read gage factor directly. The gage factor range of the DSI is from 1.75 to 2.25. In extreme cases, a particular type of strain gage may have a gage factor outside this range. Data will then require correction, according to the following relation:

$$\text{Actual Strain} = \text{Indicated Strain} \times \frac{\text{Indicated Gage Factor}}{\text{Actual Gage Factor}}$$

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CALIBRATION CHECK

The pushbutton labeled CALIBRATION CHECK is for the purpose of shunting a known value of resistance across one arm of the input bridge. This operation creates a known resistance change which may be used to check the calibration of the indicator. The equivalent value of strain IN ONE ACTIVE ARM to produce an output signal which is the same as caused by the shunt calibration resistor is given by

$$\text{STRAIN} = -\frac{10^6 R}{k\ (R_c + R/2)} \text{ microinches per inch}$$

where R is the strain gage resistance in ohms

R_c is the shunt calibrating resistance in ohms

k is the gage factor of the strain gage

It should be noted that the strain calculated from the above formula is based on a linear relation between strain and millivolts per volt bridge output. Although this is approximately true for small strains, the indicator reading must be corrected for non-linear bridge output for an exact correlation.

The calibration resistor supplied with the instrument is 60K ohms ±.05%. It is mounted on a replaceable plug at the rear of the instrument. This resistor is normally wired to shunt R-1 (Fig. 1) when the front panel CALIBRATION CHECK pushbutton is operated. The plug may be rewired (or an inexpensive replacement is available from AMPHENOL as their Cat. No. 70-26) if other calibration resistor values or other bridge shunting arrangements are required.

Direct calibration of an external bridge input by causing a known resistance change to occur assures maximum accuracy provided that the gage resistances are known accurately and lead resistances are insignificant. The shunt calibration circuit is also useful to ascertain the error caused by lead resistance when long input leads are used.

GENERAL RESISTANCE BRIDGE MEASUREMENTS

When resistance bridge transducers other than strain gages are employed, it will be necessary to determine their individual calibrations. For a two active arm resistance bridge, with the GAGE FACTOR control set at 2.00, and with MULTIPLIER set at position 2, a resistance change of 0.200% will cause a full scale reading. This resistance change corresponds to an open circuit output of 1.000 millivolts per volt applied bridge voltage. The instrument calibration in percent resistance change or millivolts per volt will change proportionally for other settings of the MULTIPLIER control, and will also vary for settings of the GAGE FACTOR control other than 2.00. The resistance change PER ARM for fullscale is inversely proportional to the number of active arms. Table 2 summarizes the various possible combinations of MULTIPLIER settings and number of active arms, and the resultant overall instrument calibration.

TABLE 2: SUMMARY OF INSTRUMENT CALIBRATION

(FULL SCALE = 1000 COUNTS)

MULTI-PLIER	No. of ACTIVE ARMS	STRAIN (Micro-inches per inch) (SEE NOTE 2)	RESISTANCE CHANGE PER ARM (SEE NOTE 2)	MILLIVOLTS PER VOLT (SEE NOTE 1)
1	1	1000	0.200%	0.500
	2	500	0.100	0.500
	4	250	0.050	0.500
2	1	2000	0.400	1.00
	2	1000	0.200	1.00
	4	500	0.100	1.00
4	1	4000	0.800	2.00
	2	2000	0.400	2.00
	4	1000	0.200	2.00
10	1	10,000	2.00	5.00
	2	5,000	1.00	5.00
	4	2,500	0.50	5.00
100	1	100,000	20.0	50.0
	2	50,000	10.0	50.0
	4	25,000	5.0	50.0

(1) OPEN CIRCUIT VOLTAGE OUTPUT OF INPUT BRIDGE, WITH GAGE FACTOR SET AT 2.00

(2) CORRECTION IS REQUIRED FOR NON-LINEAR BRIDGE OUTPUT WITH ONE ACTIVE ARM, PARTICULARLY FOR LARGE SIGNALS.

When dealing with millivolts per volt, or resistance change per arm, it will be necessary to determine the correct multiplier for the indicated reading taking into account settings of both the MULTIPLIER and GAGE FACTOR controls, as follows:

$$\text{Millivolts per volt} = \frac{\text{Counts}}{1000} \times \frac{\text{GAGE FACTOR setting}}{4} \times \text{MULTIPLIER setting}$$

or,

$$\text{Percent resistance change per arm} = \frac{\text{Counts}}{1000} \times \frac{\text{GAGE FACTOR setting}}{10} \times \frac{\text{MULTIPLIER}}{\text{No. of Active Arms}}$$

BRIDGE LOADING ERRORS

The input impedance of the DSI at signal lead 1 (pin B), is 500,000 ohms and at signal lead 2 (pin E), input impedance is 250,000 ohms (COARSE BALANCE switch at EXT.). Except for measurements where the open circuit output voltage of high resistance bridges must be accurately determined, the loading effect of the DSI can usually be neglected. In fact, for critical full bridge measurements, the loading effect of the zero balance control is usually an order of magnitude greater, and may have to be accounted for.

5. MAINTENANCE AND ADJUSTMENT

The DSI is conservatively designed to utilize stable, low noise components in the input circuit. Accuracy is independent of vacuum tube characteristics, and critical adjustments are not required.

Standard receiving tubes are employed, which may have to be checked or replaced in the event of indicator malfunction. Another possible source of difficulty is the chopper-modulator, which, after long usage, may increase in noise level such that servo operation deteriorates noticeably. Symptoms such as excessive "jitter" or sudden erratic operation can possibly be traced to either the chopper-modulator or to an excessively noisy potentiometer.

Abnormally high instrument zero offset can result from hum pickup at the grid of the first amplifier tube. Replacement of this tube and careful attention to grounding of the instrument chassis and cabinet should limit the zero offset to less than 5 counts. Use of standard test equipment for observing amplifier waveforms, and for checking voltages and resistances, can usually give indication to the source of amplifier difficulty. Troubles such as excessive zero drift, unstable operation, calibration errors, etc., are usually traceable to the input circuits. Most of the resistors in the input circuit are close tolerance (+0.1%) and before replacement should be checked with a precision wheatstone bridge.

The servo motor-worm gear potentiometer assembly must be properly adjusted and lightly lubricated for proper performance. A unique, rugged stop assembly is integral with the worm gear, and is actuated at the end of the potentiometer travel to absorb the major stop lead. These auxiliary stops should be adjusted at each end of the servo travel for proper action. In general, this adjustment will require rotation of each stop washer with respect to the worm gear. Keys on each stop washer engage slots in each end of the worm gear, and relative rotation in increments of 90^{o} is possible. In addition, the stationary stops attached to the casting are adjustable inward and outward as required. Final adjustment should be such that the tang on the stop washer fully engages the corresponding stationary stop when the instrument is driven off-scale, but with sufficient clearance during normal operation to prevent premature engagement of the stops. Excessive sliding friction can also cause premature stop engagement, and can also cause an apparent zero shift, so this assembly should receive occasional light lubrication with oil such as "Nyes Clock Oil".

In instruments where a Coleman Digitizer is furnished, both the Digitizer and its mounting plate must be removed for access to the servo assembly. White index marks on the Digitizer contact wheels and contact plate, visible through the lucite cover, are aligned for "000". When re-installing, the Digitizer drive gear must be set so that these index marks are aligned when the visual readout counter is also at "000".

ELECTRICAL ADJUSTMENTS

Where readjustments of factory-set calibration controls is required, the following sequence of adjustment should be observed, with a 120 ohm ±0.05% half or full bridge connected to the input binding posts:

(1) With MULTIPLIER at 100, depress CHECK INSTRUMENT ZERO pushbutton and set counter to zero with ADJUST INSTRUMENT ZERO potentiometer.

(2) Set MULTIPLIER to 1, zero instrument with BALANCE controls, and operate CHECK INSTRUMENT ZERO pushbutton to check zero offset. The offset will normally be less than 5 counts with the instrument in a grounded cabinet, or with a grounded metal plate beneath the chassis if removed from the cabinet.

(3) Set GAGE FACTOR to 2.25 and adjust BALANCE controls to obtain count of 700.

(4) Set GAGE FACTOR to 1.75 and adjust GAGE FACTOR RANGE potentiometer to obtain count of 900.

(5) Set GAGE FACTOR to 2.00 and adjust BALANCE controls to obtain count of +10.

(6) Depress CALIBRATION CHECK pushbutton and adjust CALIBRATE ADJUST potentiometer to obtain count of −989 (be sure calibrate resistor is connected to "+" and "S1" socket pins to avoid loading effect of balancing circuit, which is connected to "S2" terminal).

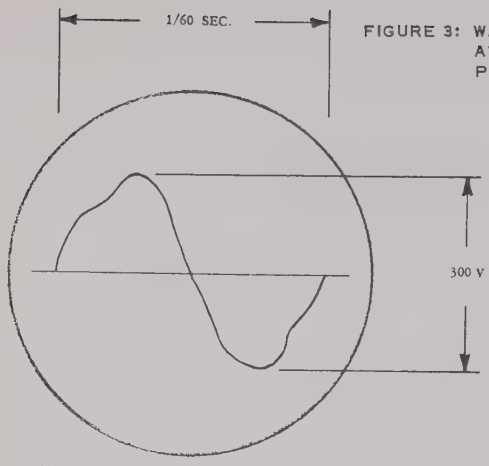
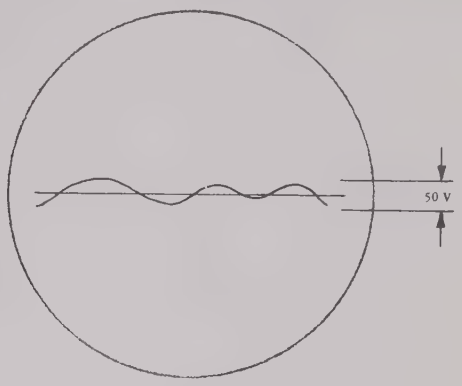


FIGURE 3: WAVEFORMS AT 6AQ5 PLATES (PIN 5 OF V103 AND V104). WAVEFORMS AT EACH PLATE SHOULD BE OF EQUAL AMPLITUDE, BUT 180° OUT OF PHASE.

A. FULL UNBALANCE SIGNAL, MULTIPLIER ON 1, AND WITH SERVO GAIN ADJUSTED FOR "SNAPPY" SERVO PERFORMANCE.



B. RESIDUAL SIGNAL, SERVO AT BALANCE POINT

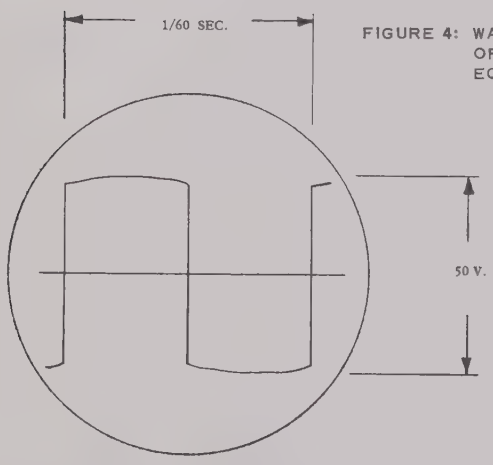
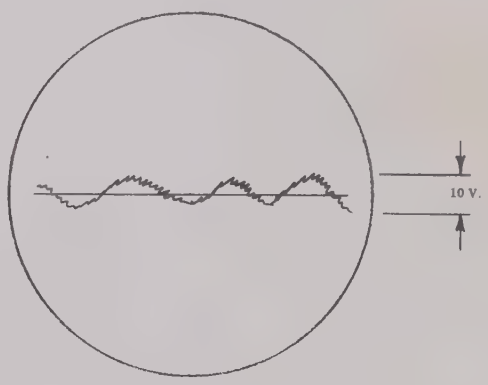


FIGURE 4: WAVEFORMS AT INPUT TO 6AQ5 GRIDS (MEASURED AT JUNCTION OF 330K RESISTORS) WAVEFORMS AT EACH GRID SHOULD BE EQUAL AMPLITUDE, BUT 180° OUT OF PHASE.

A. FULL UNBALANCE SIGNAL, MULTIPLIER ON 1, AND WITH SERVO GAIN ADJUSTED FOR "SNAPPY" SERVO PERFORMANCE



B. RESIDUAL SIGNAL, SERVO AT BALANCE POINT

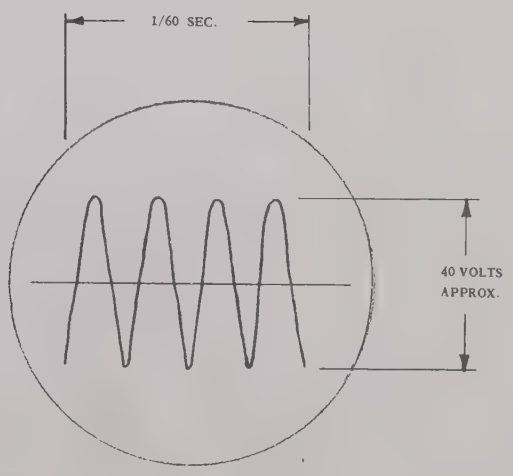


FIGURE 5: WAVEFORMS AT INPUT TO 6AQ5 GRID (MEASURED AT JUNCTION OF 330K RESISTORS) FOR CONDITION OF EXCESSIVE 60 CYCLE PICKUP ON SIGNAL LEADS.

TROUBLE SHOOTING

Probably the most common difficulty in normal DSI usage arises because of excessive AC pickup on signal leads. This generally manifests itself as sluggish servo response near the balance point, and as excessive motor "buzz" which disappears when amplifier gain is reduced. It should be remembered that an unwanted signal of only a few microvolts can drive the servo amplifier to saturation, thereby preventing proper response to the desired signal. Although the design of the DSI input circuits affords a high degree of discrimination to unwanted AC signals, still under some conditions trouble may be experienced. As previously indicated, half bridge inputs are particularly susceptible. The use of shielded input leads and grounding of one or the other of the bridge power leads to the DSI case will generally solve this problem. Duplicate ground points in any portion of the input bridge circuit should be avoided.

Another easy-to-diagnose difficulty is excessive "buzz" of the servo motor, which persists even at the extreme counterclockwise setting of the SERVO GAIN control. This is generally caused by one of the 6AQ5 power amplifier tubes being defective, creating an unbalanced output stage and reduced motor torque. Failure of a 12AX7 voltage amplifier tube is rare, but they should be checked, or a tube which is known to be good substituted, if amplifier performance is suspected.

The voltage and resistance measurements given in Tables 3 and 4 should aid in trouble shooting of the amplifier circuits. Table 5 measurements may be helpful in case of input circuit difficulty.

TABLE 3: VOLTAGE MEASUREMENTS AT AMPLIFIER TUBES

TUBE PIN NUMBER	V101 (12AX7)	V102 (12AX7)	V103, 104 (6AQ5)
1	90	130	0
2	0	0	16(2)
3	1.3	1.6	3.1AC
4	3.1AC	3.1AC	3.1AC
5	3.1AC	3.1AC	265
6	135	130	275
7	0	0	0
8	1.5	1.6	-
9	3.1AC	3.1AC	-

NOTE: (1) ALL MEASUREMENTS MADE WITH VTVM, 10 MEGS INPUT RESISTANCE
(2) AT SERVO BALANCE POINT. INCREASES TO APPROXIMATELY 20 VOLTS AT MAX. SERVO UNBALANCE.

TABLE 4: RESISTANCE MEASUREMENTS AT AMPLIFIER TUBES

TUBE PIN NUMBER	V101 (12AX7)	V102 (12AX7)	V103, V104 (6AQ5)
1	5 MEG (2)	5 MEG (2)	660K
2	20K	500K	200
3	10K	6.8K	0
4	0	0	0
5	0	0	500K (2)
6	4 MEG (2)	5 MEG (2)	500K (2)
7	1 MEG	6.8K	660K
8	6.8K	6.8K	-
9	0	0	-

NOTE: (1) TURN POWER OFF AND DISCHARGE ALL ELECTROLYTIC CAPACITORS BEFORE MEASURING. MEASUREMENTS MADE WITH 20,000 OHMS PER VOLT MULTIMETER.
(2) MEASUREMENT INDICATED AFFECTED BY ELECTROLYTIC CAPACITOR. MEASURED VALUE SHOULD BE EQUAL TO, OR HIGHER THAN, VALUE SHOWN.

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TABLE 5: RESISTANCE MEASUREMENTS AT BINDING POSTS

I. (+) TO (–) (SEE NOTE 1)

A. GAGE FACTOR @ 2.25: R = 281 OHMS

B. GAGE FACTOR @ 1.75: R = 309 OHMS

II. (+) AND (–) TO (S2) (SEE NOTE 1)

A. BRIDGE SWITCH @ HALF; COARSE BALANCE @ EXT.: GAGE FACTOR @ 200: R = 194 OHMS

B. BRIDGE SWITCH @ FULL; R IS TABULATED BELOW FOR ALL SETTINGS OF THE COARSE BALANCE SWITCH AND AT THREE SETTINGS OF THE FINE BALANCE POTENTIOMETER:

COARSE BALANCE	FINE BALANCE CCW	FINE BALANCE CENTER	FINE BALANCE CW
0	17.7K	20.0K	17.6K
–2	16.1K	19.8K	19.0K
+2	19.0K	19.7K	16.0K
–6	8.81K	14.5K	15.0K
+6	14.9K	14.3K	8.54K

(+) OR (–) TO (S1) (SEE NOTES 1 & 2)

BRIDGE SWITCH @ HALF, COARSE BALANCE @ EXT., GAGE FACTOR @ 2.00

MULTIPLIER	R
1	1.403K
2	2.520K
4	4.737K
10	11.28K
100	92.0K

IV. (S1) TO (S2) (SEE NOTES 1 & 2)

BRIDGE SWITCH @ FULL, COARSE BALANCE @ EXT., GAGE FACTOR @ 2.00

MULTIPLIER	R
1	1.210K
2	2.331K
4	11.17K
10	97.9K

NOTES:

1. REMOVE JUMPER PLUG AT REAR OF DSI CHASSIS.
2. THE MEASUREMENTS INDICATED ARE ON ±0.1% TOLERANCE CIRCUITS AND WERE MADE USING AN ELECTRO-MEASUREMENTS, INC. IMPEDANCE BRIDGE. THE CHOPPER-MODULATOR MUST BE IN ITS SOCKET FOR THESE MEASUREMENTS.

PARTS LIST, ELECTRICAL COMPONENTS

DIGITAL STRAIN INDICATOR, MODEL A–110

SYMBOL (SCHEMATIC) (DWG. 6193)	DESCRIPTION (SEE NOTE 1)	MANUFACTURER'S CATALOG TYPE (SEE NOTE 1)
C1	Capacitor, 200 V, 10 MFD	Hopkins 10PD
C2	Capacitor, 200 V, .033 MFD	Sprague 2WF-S33
C101	Capacitor, 600V, .006 MFD	Molded Tubular
C102, C104	Capacitor, 400V, .05 MFD	Molded Tubular
C103, C105	Capacitor, 25V, 25 MFD	Electrolytic
C106, C107	Capacitor 400 V, .1 MFD	Molded Tubular
C108, C109	Capacitor 400 V, 1 MFD	Cornell-Dubilier CP61B1EE 105K
C110	Capacitor 50V, 25 MF	Electrolytic
C111	Capacitor 450 V, 4 x 20 MFD	Mallory FP444
C112	Capacitor, 220VAC, 1 MFD	Aerovox P89D193
C113, 114	Capacitor, 15V, 6000MFD	Mallory BC1560
C115	Capacitor, 200V, .5 MFD	Hopkins P52D
CM101	Chopper Modulator, AC-DC	James C-1282
CR101	Rectifier, Selenium	Int'l. Rectifier J29B04
CR102-CR105	Rectifier, Silicon	Texas Instruments IN2071
F101	Fuse, 1-1/2 Amp. Type 3AG	Littelfuse 31201.5
I101	Indicating Lamp	Type 328
J1	Connector, 9 pin	Amphenol 165-16
--	Mating Input Connector	Amphenol 165-13
Input Terminals	Binding Post	H.F. Johnson 111-103
J2,J3	Socket	Amphenol 77-26
--	Mating Plug	Amphenol 70-26
R1, R2	Resistor, 561.9 ohms ±0.1%	Precision Wire Wound
R3, R4	Resistor, 560.6 ohms ± 0.1%	Precision Wire Wound
R5, R6	Resistor, 1117.4 ohms ±0.1%	Precision Wire Wound
R7, R8	Resistor, 3322.5 ohms ±0.1%	Precision Wire Wound
R9, R10	Resistor, 45000 ohms ±0.1%	Precision Wire Wound
R11	Resistor, 444.4K ohms ±0.1%	Precision Wire Wound
R12	Resistor, 447.0K ohms ±0.1%	Precision Wire Wound
R13	Resistor, 495.0Kohms ±0.1%	Precision Wire Wound
R14A,R14B	Dual Potentiometer, 10K ohms	I. R. C. WPRL, 10000 &WM10000
R15	Dual Potentiometer, 2K ohms	Spectrol Type 810
R16	Potentiometer, 100 ohms	I. R. C. WPRL 100
R17, R18	Resistor, 5000 ohms ±0.1%	Dalohm Type RS2A
R19	Resistor, 2700 ohms ±1%	Dalohm Type RS2A
R20	Potentiometer, 750 ohms	I. R. C. WPRL 750
R21	Dual Potentiometer, 200 ohms	General Radio Type 971-C
R26, R27	Precision Half-Bridge, 240 ohms	Datran Part 6107
R28	Precision Dummy Resistor, 120 ohms	Datran Part 6206
R29	Potentiometer, 20K ohms	Spectrol Type 860
R30	Resistor, 20K ohms ±1%	Dalohm Type, RS2A
R31, R32	Resistor, 11.0K ohms ±1%	Dalohm Type RS2B
R33, R34	Resistor, 17.5K ohms ±1%	Dalohm Type RS2B
R35, R36	Resistor, 30.0K ohms ±1%	Dalohm Type RS2
R37, R38	Resistor, 27.5K ohms ±1%	Dalohm Type RS2
R39	Resistor, 9.0K ohms ±1%	Dalohm Type RS2B
Calibration Check	Resistor, 60K ohms ±0.05%	Precision Wire Wound
R101, 103, 107, 108	Resistor, 1.0 megohms ±10%	Ohmite 1/2 watt
R102	Resistor, 10K ohms ±10%	Ohmite 1/2 watt
R104, R124	Resistor, 0.47 megohms ± 10%	Ohmite 1/2 watt

PARTS LIST, ELECTRICAL COMPONENTS

DIGITAL STRAIN INDICATOR, MODEL A–110

SYMBOL (SCHEMATIC) (DWG 6193)	DESCRIPTION (SEE NOTE 1)	MANUFACTURER'S CATALOG TYPE (SEE NOTE 1)
R105, R109, R113	Resistor, 6.8K ohms ±10%	Ohmite 1/2 watt
R106	Potentiometer, 1 megohm	I. R. C. PQ13-137
R110, R111, R112, R115	Resistor, 330K ohms, ±10%	Ohmite 1/2 watt
R114	Resistor, 200 ohms ±5%	Dalohm RS-5
R116	Resistor, 750 ohms ±10%	Ohmite 20 watts
R117	Resistor, 33K ohms ±10%	Ohmite 1/2 watt
R118	Resistor, 39K ohms ±10%	Ohmite 1/2 watt
R119	Resistor, 150K ohms ±10%	Ohmite 1/2 watt
R120, R121, R122, R123	Resistor, 10 ohms ±10%	Ohmite 2 watt
S1	Switch, Rotary, 2 position	Centralab PA1000
S2	Switch, Rotary 6 position	Centralab PA1014
S3	Switch, Rotary, 5 position	Centralab PA1016
S4	Switch, Pushbutton, Momentary	Microswitch 2PB11T
S5	Switch, Pushbutton, Momentary	Microswitch 2PB15T
S101	Switch, Power Toggle	Cutler-Hammer 7618-K2
SM101	Servomotor, 2 phase, 60 cycle	Holtzer-Cabot CS-5270
T101	Transformer, Input	Triad G-20
T102	Transformer, Power	Triad R12A
V101, V102	Vacuum Tube	12AX7
V103, V104	Vacuum Tube	6AQ5

NOTE:

1. In some instances, parts of equivalent quality and performance specifications may have been substituted, at the time of manufacture, for parts listed.
2. Omissions may occur in numerical sequence of parts symbols.

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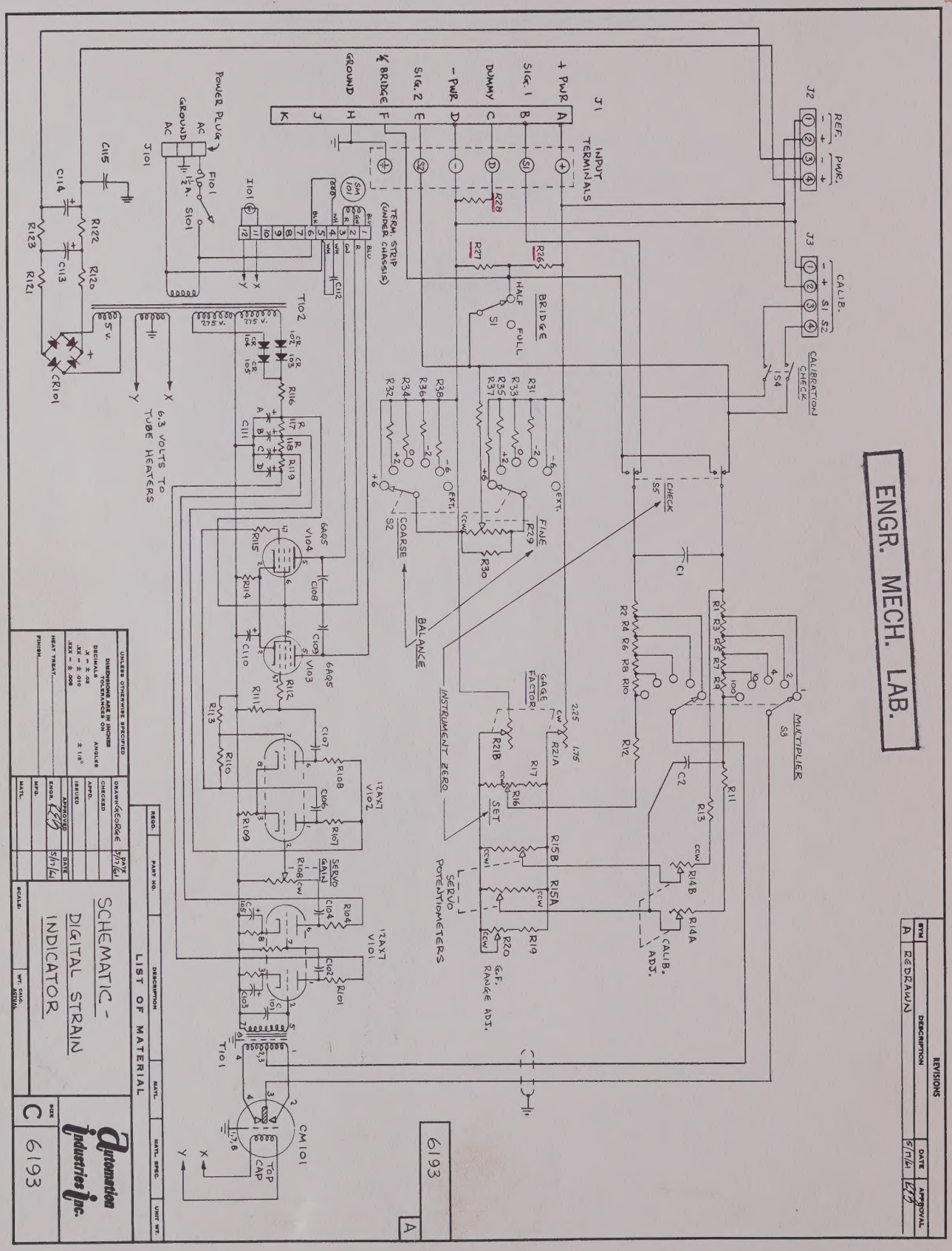

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